



Implementation of Problem-Based Learning in CAD Instruction for Automotive Engineering Students: Classroom Action Research on Engagement and Learning Outcomes

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Abstract

Low student engagement and modest Computer-Aided Design (CAD) learning outcomes remain challenges in automotive engineering education. This study examined the implementation of Problem-Based Learning (PBL) to support student engagement and CAD learning achievement in an Automotive Engineering course. A Classroom Action Research design was conducted in two cycles comprising planning, action, observation, and reflection. The participants were 25 Automotive Engineering students in the 2025/2026 even semester. Data were collected through observation, pre-test, post-test, and documentation, and analyzed descriptively. The results showed that learning mastery increased from 72% in Cycle I to 88% in Cycle II, while the average score increased from 70.04 to 78.48. Classroom observations also indicated more active participation in discussion, problem-solving, group work, and presentations. These findings suggest that PBL can support CAD learning achievement and student engagement in this classroom action context.

Keywords

Problem-Based Learning; student engagement; CAD learning achievement; Classroom Action Research; automotive engineering education.

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INTRODUCTION

Automotive engineering education is expected to prepare students who are able to work with digital design tools, solve technical problems, and adapt to current automotive industry demands. Recent studies in automotive vocational education have emphasized that graduates need competencies aligned with technological development, industry standards, and workplace readiness [1]. In this context, learning innovation is essential because automotive courses increasingly require students to combine conceptual understanding, practical skills, and digital tool operation. Previous studies in AEEJ have shown that instructional improvement in automotive education can be supported through learning modules, smart trainers, and technology-integrated learning media that help students understand technical concepts more actively and systematically [2], [3].

Computer-Aided Design (CAD) is one of the important courses in automotive engineering because it trains students to visualize, model, and communicate engineering components digitally. In automotive-related design learning, CAD is not only used to draw objects but also to develop students' ability to interpret dimensions, transform two-dimensional information into three-dimensional models, and produce technical drawings that meet design



requirements. Research on CAD learning in engineering education has shown that CAD tasks require iterative design actions, software familiarity, and problem-solving ability, making student engagement an important factor in successful learning [4]. Studies on cloud-based and online CAD teaching also indicate that CAD instruction needs structured guidance, demonstrations, practice opportunities, and learning support because students may experience difficulty when learning complex modelling procedures independently [5], [6].

Despite the importance of CAD competence, learning difficulties are still commonly found in CAD courses. Students may become passive when learning is dominated by lecturer explanation, step-by-step demonstration, or routine drawing assignments without sufficient opportunities to analyze design problems. In such conditions, students tend to wait for instructions rather than actively ask questions, discuss alternatives, or justify their technical decisions. This is problematic because CAD learning requires not only software operation but also active reasoning, precision, collaboration, and decision-making during the design process. Therefore, a learning model is needed that can position students as active problem solvers while still providing structured learning support.

Problem-Based Learning (PBL) offers a relevant instructional approach for CAD learning because it uses contextual problems as the starting point for learning. Through PBL, students are encouraged to identify problems, collect information, discuss possible solutions, develop design alternatives, and present the results of their work. In vocational learning contexts, problem-based and project-oriented instructional models have been reported to support students' learning outcomes because they connect learning activities with authentic tasks and practical problem-solving processes [7]. A meta-analysis on PBL also indicates that problem-based instruction has a positive contribution to students' learning outcomes across different educational contexts [8]. In automotive vocational education, the development of a Teaching Factory model with a PBL concept has shown that problem-based learning environments can support problem-solving and communication skills when students are exposed to contextual technical tasks [9].

In CAD learning, PBL is particularly relevant because design activities naturally involve problem analysis, modelling decisions, design revision, and presentation of technical solutions. Previous research on CAD courses has shown that design-based and project-based learning can improve the quality of learning when students are required to complete design products, collaborate, and apply engineering knowledge in practical tasks [10]. Recent vocational studies also show that PBL combined with digital or e-learning support can strengthen learning quality and student outcomes when the learning process is organized around problem-solving activities [11], [12]. However, many previous CAD-related studies have focused on software use, project completion, or technical skill development, while fewer studies have examined how PBL can be used specifically to support both student engagement and CAD learning achievement in an Automotive Engineering course.

Based on this gap, this study focuses on the implementation of PBL in a CAD course for Automotive Engineering students. The study is designed as Classroom Action Research to observe improvement across learning cycles, particularly in student engagement and learning achievement. The contribution of this study lies in providing classroom-based evidence on how PBL can be implemented in CAD learning through planning, action, observation, and reflection. Rather than claiming broad causal impact, this study examines observed improvement within a specific classroom context involving Automotive Engineering students. Therefore, this study aims to examine the implementation of PBL to support student engagement and CAD learning achievement in an Automotive Engineering course.

METHOD

This study employed a Classroom Action Research (CAR) design to support the improvement of student engagement and learning achievement in the Computer-Aided Design (CAD) course through the implementation of Problem-Based Learning (PBL). CAR was selected because it enables instructional improvement through repeated cycles of planning, action, observation, and reflection in the actual classroom context [13]. The study began with a preliminary observation to identify learning problems in the CAD course, followed by two action cycles. Each cycle was used to implement the learning action, observe student engagement and learning achievement, and reflect on the results before determining whether improvement was needed in the next cycle.

The research was conducted in the even semester of the 2025/2026 academic year, from February to April 2026. The participants were 25 students of the Automotive Engineering Study Program who were enrolled in the CAD course. The learning intervention was implemented using the PBL model, in which students were given contextual automotive design problems that required them to analyze design requirements, discuss possible solutions, complete CAD-related tasks, and present their work individually and in groups. This procedure was aligned with problem-based learning principles in STEM and vocational learning, which emphasize authentic problems, student inquiry, collaborative work, and reflection as part of the learning process [7], [14].

As shown in Figure 1, the CAR procedure consisted of two cycles based on the Kemmis and McTaggart model. Each cycle included four main stages: planning, action implementation, observation, and reflection. In the planning stage, the researcher prepared learning materials, lesson plans, observation sheets, and evaluation instruments. In the action implementation stage, the PBL activities were carried out using automotive design problems related to CAD learning. In the observation stage, student engagement was recorded during the learning process, including participation in discussions, questioning, problem-solving activities, group work, and presentations. In the reflection stage, the researcher and the collaborating lecturer reviewed the learning process and student achievement to determine improvements for the next cycle. If the expected engagement and learning achievement criteria had not been reached, the action was revised and continued in the following cycle.

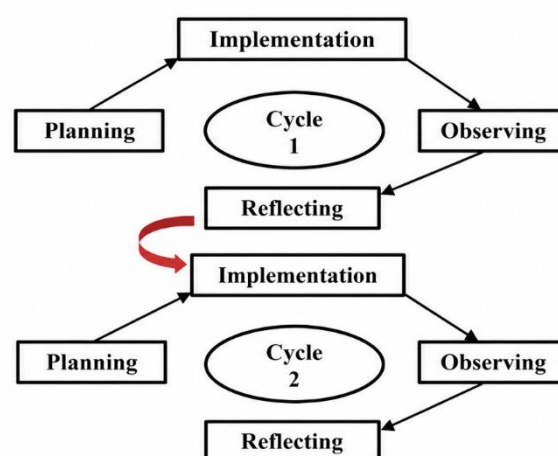


Figure 1. Classroom Action Research design based on the Kemmis and McTaggart model.

Data were collected through observation, pre-test, post-test, and documentation. Observation sheets were used to record student engagement during the PBL process, while pre-test and post-test scores were used to measure students' CAD learning achievement before and

after the action cycles. Documentation was used to support the recording of learning activities and classroom implementation. The use of observation and test-based assessment is relevant in PBL and vocational education because student engagement and learning outcomes need to be captured through both behavioural participation and achievement evidence [15], [16].

The observation process was conducted by the researcher and a collaborating lecturer using the same observation sheet to improve consistency in recording student engagement. Learning achievement was evaluated using the established passing standard of 70, and learning mastery was calculated as the percentage of students who achieved a score of 70 or higher. The expected engagement criterion was set at an average engagement score of at least 75%. Student engagement was analyzed using percentage scores from the observation sheet, while learning achievement was analyzed using the average score and the percentage of students who achieved learning mastery. The data from observation, pre-test, post-test, and documentation were analyzed descriptively to identify changes in student engagement and CAD learning achievement across the pre-action stage, Cycle I, and Cycle II. Therefore, the results of this study were interpreted as observed classroom improvement across action cycles rather than as causal evidence from an experimental comparison.

RESULTS AND DISCUSSION

Pre-Action Stage

Before the pre-action activities were conducted, the researcher first established the score classification criteria used to interpret students' CAD learning achievement. The classification criteria are presented in Table 1 and were used consistently to categorize the pre-test and post-test results.

Table 1. Score classification criteria for CAD learning achievement

Rating Weight	Quality Value	Quality Score	Information
85–100	A	4	With Compliments
80–84	A-	3.6	Very Very Good
75–79	B+	3.3	Very Well
70–74	B	3	Good
65–69	B-	2.6	Pretty Good
60–64	C+	2.3	More Than Enough
55–59	C	2	Enough
50–54	C-	1.6	Not Enough
40–49	D	1	Less
≤39	E	0	Failed
-	T	-	Delayed

The pre-action stage was conducted to identify students' initial understanding before the implementation of Cycle I and Cycle II. Preliminary observations and interviews with the course lecturer indicated that students were generally passive during CAD practice sessions, frequently encountered difficulties in interpreting two-dimensional information into three-dimensional automotive components, and lacked confidence in solving open-ended design problems. These initial conditions indicated the need for a problem-based learning intervention. Students then completed an initial written multiple-choice test as a pre-test. The pre-test results are presented in Table 2.

Table 2. Pre-test scores in the pre-action stage

No	Respondent	Score	Description
1	X1	54	Not Enough
2	X2	70	Good
3	X3	52	Not Enough
4	X4	55	Enough
5	X5	73	Good
6	X6	80	Very Very Good
7	X7	70	Good
8	X8	75	Very Well
9	X9	0	Failed
10	X10	83	Very Very Good
11	X11	70	Good
12	X12	60	More Than Enough
13	X13	65	Pretty Good
14	X14	55	Enough
15	X15	70	Good
16	X16	73	Good
17	X17	70	Good
18	X18	65	Pretty Good
19	X19	83	Very Very Good
20	X20	80	Very Very Good
21	X21	50	Not Enough
22	X22	80	Very Very Good
23	X23	80	Very Very Good
24	X24	54	Not Enough
25	X25	55	Enough
Final Score		1622	
Average		64.88	

Based on [Table 2](#), students' initial mastery in the pre-action stage was still below the expected learning standard. Of the 25 students, 14 students, or 56%, reached the minimum passing score of 70, while 11 students, or 44%, had not yet reached the passing score. The average pre-test score was 64.88. Furthermore, the score of 0 recorded for respondent X9 was retained according to the original assessment record and included in the descriptive analysis to maintain the completeness of the classroom dataset. The score distribution consisted of 6 students, or 24%, in the Very Very Good category; 1 student, or 4%, in the Very Well category; 7 students, or 28%, in the Good category; 2 students, or 8%, in the Pretty Good category; 1 student, or 4%, in the More Than Enough category; 3 students, or 12%, in the Enough category; 4 students, or 16%, in the Not Enough category; and 1 student, or 4%, in the Failed category.

Classroom Action Research: Cycle I

Cycle I was conducted through planning, action implementation, observation, and reflection. The action in this cycle was implemented in two sessions using the Problem-Based Learning model. Observation was conducted to identify student engagement during CAD learning activities, including participation in discussions, questioning, problem-solving activities, group work, and presentations. During Cycle I, several students were still not fully

focused and did not consistently participate in the learning process. The student engagement data for Cycle I are presented in [Table 3](#).

Table 3. Percentage of student learning engagement in Cycle I

No.	Respondent	Session I (%)	Session II (%)
1	X1	37.5	45.83
2	X2	41.66	54.16
3	X3	50	62.5
4	X4	50	54.16
5	X5	58.33	62.5
6	X6	37.5	45.83
7	X7	37.5	41.66
8	X8	70.83	75
9	X9	0	0
10	X10	62.5	66.66
11	X11	37.5	41.66
12	X12	37.5	45.83
13	X13	33.33	41.66
14	X14	33.33	41.66
15	X15	41.66	50
16	X16	33.33	45.83
17	X17	41.66	45.83
18	X18	62.5	66.66
19	X19	66.66	70.83
20	X20	54.16	62.5
21	X21	33.33	41.66
22	X22	58.33	62.5
23	X23	37.5	41.66
24	X24	66.66	66.66
25	X25	41.66	50
Final Score		1124.93	1283.24
Average		45	51.33

As presented in [Table 3](#), the average student engagement increased from 45.00% in Session I to 51.33% in Session II. Although engagement improved between sessions, the average engagement level in Cycle I remained below the expected target of 75%. The engagement pattern across the two sessions is illustrated in [Figure 2](#).

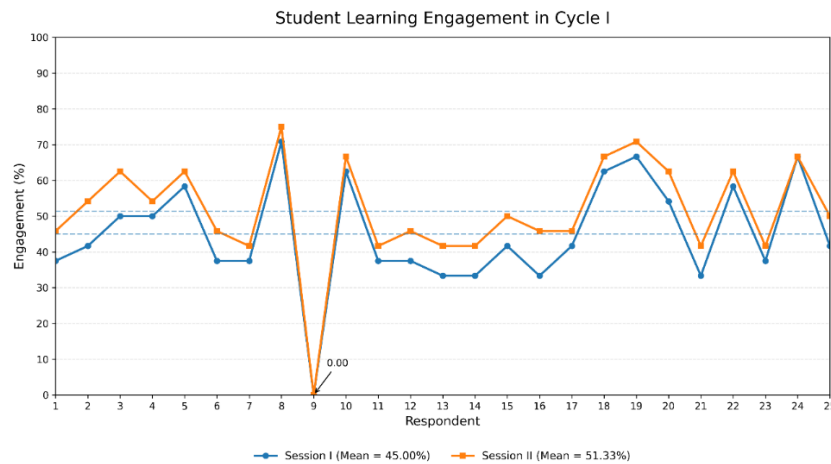


Figure 2. Student engagement percentages in Cycle I across Session I and Session II.

After Cycle I was completed, students took Post-Test I to evaluate their learning achievement after the first action cycle. The post-test results for Cycle I are presented in Table 4.

Table 4. Post-test scores in Cycle I

No.	Respondent	Score	Description
1	X1	76	Very Well
2	X2	75	Very Well
3	X3	72	Good
4	X4	77	Very Well
5	X5	73	Good
6	X6	85	With Compliments
7	X7	72	Good
8	X8	76	Very Well
9	X9	0	Failed
10	X10	84	Very Very Good
11	X11	73	Good
12	X12	60	More Than Enough
13	X13	70	Good
14	X14	56	Enough
15	X15	75	Very Well
16	X16	77	Very Well
17	X17	83	Very Very Good
18	X18	66	Pretty Good
19	X19	85	With Compliments
20	X20	84	Very Very Good
21	X21	52	Not Enough
22	X22	85	With Compliments
23	X23	85	With Compliments
24	X24	54	Not Enough
25	X25	56	Enough
Final Score		1751	
Average		70.04	

Based on Table 4, the average score in Cycle I reached 70.04. The distribution of student achievement consisted of 4 students, or 16%, in the With Compliments category; 3 students, or 12%, in the Very Very Good category; 6 students, or 24%, in the Very Well category; 5 students, or 20%, in the Good category; 1 student, or 4%, in the Pretty Good category; 1 student, or 4%, in the More Than Enough category; 2 students, or 8%, in the Enough category; 2 students, or 8%, in the Not Enough category; and 1 student, or 4%, in the Failed category. Overall, 72% of students reached the passing score, while 28% had not yet reached the required standard. The distribution of post-test score categories in Cycle I is presented in Figure 3.

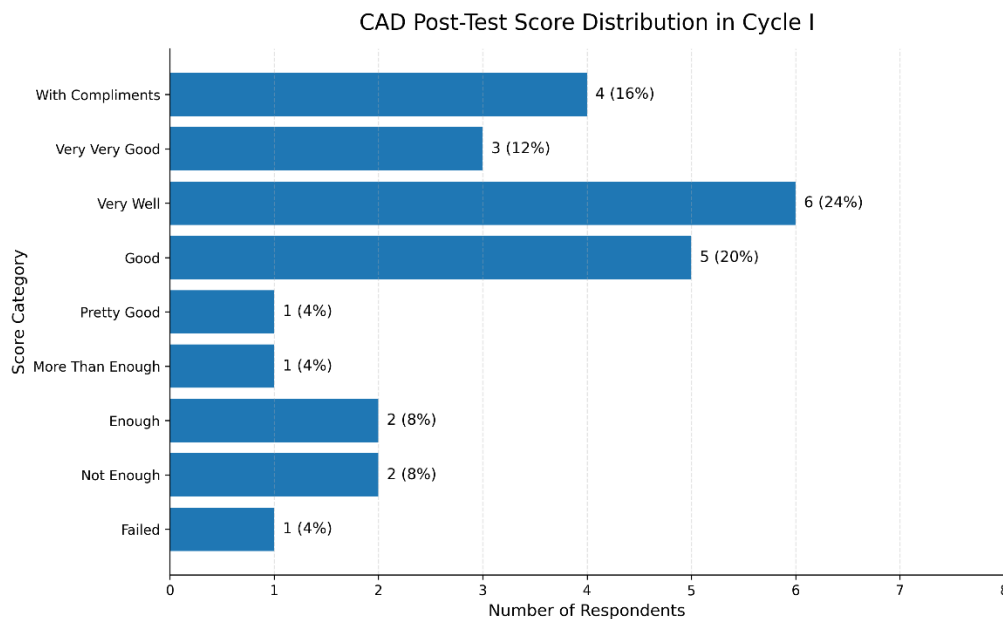


Figure 3. Distribution of CAD post-test score categories in Cycle I.

Classroom Action Research: Cycle II

Cycle II was conducted as a continuation of the reflection results from Cycle I. This cycle also included planning, action implementation, observation, and reflection. In the planning stage, the researcher revised the learning activities to improve student engagement through a more structured implementation of Problem-Based Learning. The action in Cycle II was carried out in two sessions by providing problems that were more closely related to real automotive design contexts, improving group discussion management, and strengthening feedback during learning activities. These revisions were intended to help students participate more actively, focus on the design problems, and express their ideas more confidently during CAD learning.

During the observation stage, student engagement was recorded from the beginning to the end of the learning process. The observation focused on students' participation, involvement, and responses during CAD learning activities. The engagement data for Cycle II are presented in Table 5.

Table 5. Percentage of student learning engagement in Cycle II

No.	Respondent	Session I (%)	Session II (%)
1	X1	58.33	79.16
2	X2	62.5	75
3	X3	66.66	79.16
4	X4	62.5	85
5	X5	66.66	87.33
6	X6	66.66	75

No.	Respondent	Session I (%)	Session II (%)
7	X7	54.16	86.66
8	X8	83.33	87.5
9	X9	0	0
10	X10	70.83	87.5
11	X11	50	66.66
12	X12	58.33	66.66
13	X13	54.16	75
14	X14	62.5	75
15	X15	66.66	75
16	X16	62.5	70.83
17	X17	62.5	75
18	X18	70.83	80.16
19	X19	75	87.5
20	X20	66.66	79.16
21	X21	54.16	70.83
22	X22	70.83	85.16
23	X23	58.33	75
24	X24	70.83	85.16
25	X25	66.66	70.83
Final Score		1541.58	1880.26
Average		61.66	75.21

As shown in Table 5, the average student engagement increased from 61.66% in Session I to 75.21% in Session II. The average engagement in Session II reached the expected engagement target of at least 75%. Compared with Cycle I, the engagement data in Cycle II showed higher average percentages in both sessions. The engagement pattern across the two sessions is illustrated in Figure 4.

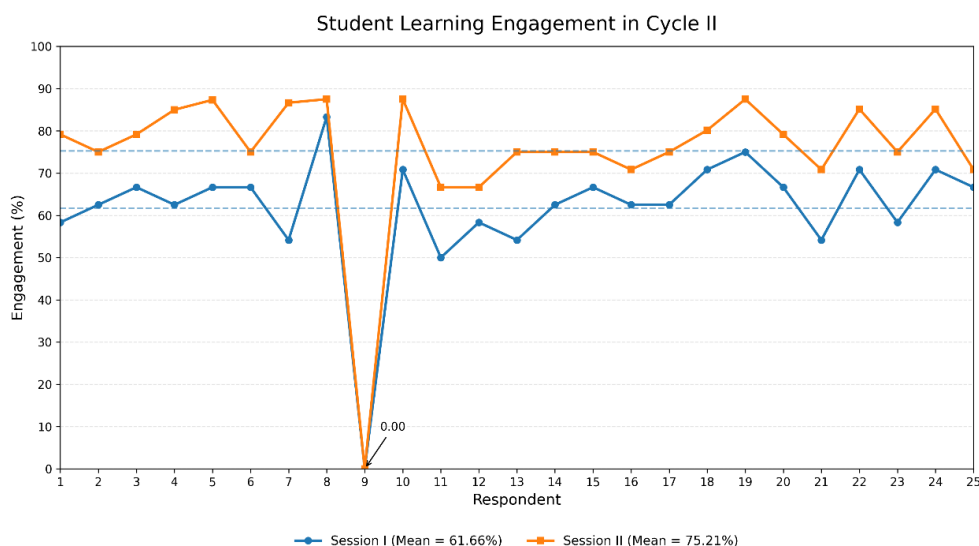


Figure 4. Student engagement percentages in Cycle II across Session I and Session II.

After the learning activities in Cycle II were completed, students took Post-Test II to evaluate their learning achievement after the second action cycle. The post-test results are presented in Table 6.

Table 6. Post-test scores in Cycle II

No.	Respondent	Score	Description
1	X1	86	With Compliments
2	X2	85	With Compliments
3	X3	75	Very well
4	X4	77	Very well
5	X5	84	Very very good
6	X6	85	With Compliments
7	X7	83	Very Very Good
8	X8	76	Very Well
9	X9	0	Failed
10	X10	88	With Compliments
11	X11	85	With Compliments
12	X12	77	Very Well
13	X13	88	With Compliments
14	X14	69	Pretty Good
15	X15	89	With Compliments
16	X16	78	Very Well
17	X17	88	With Compliments
18	X18	75	Very Well
19	X19	89	With Compliments
20	X20	84	Very Very Good
21	X21	87	With Compliments
22	X22	85	With Compliments
23	X23	85	With Compliments
24	X24	69	Pretty Good
25	X25	75	Very Well
Final Score		1962	
Average		78.48	

Based on [Table 6](#), the average score in Cycle II reached 78.48. The distribution of student achievement consisted of 12 students, or 48%, in the With Compliments category; 3 students, or 12%, in the Very Very Good category; 7 students, or 28%, in the Very Well category; 2 students, or 8%, in the Pretty Good category; and 1 student, or 4%, in the Failed category. Overall, 88% of students reached the passing score, while 12% had not yet reached the required standard. The distribution of post-test score categories in Cycle II is presented in [Figure 5](#).

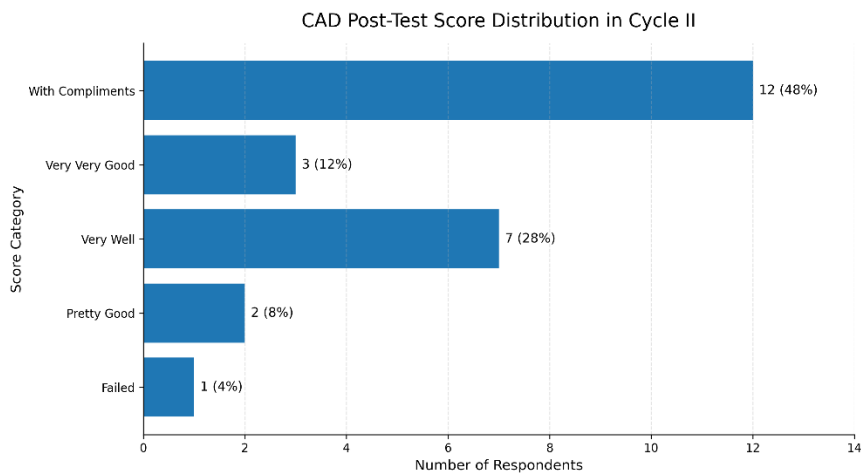


Figure 5. Distribution of CAD post-test score categories in Cycle II.

Discussion

The findings indicate an observed improvement in both student engagement and CAD learning achievement across the classroom action cycles. Based on Table 3 and Figure 2, student engagement in Cycle I increased from 45.00% in Session I to 51.33% in Session II, but the average engagement level had not yet reached the expected target. After the learning process was revised in Cycle II, Table 5 and Figure 4 show that engagement increased from 61.66% in Session I to 75.21% in Session II. This pattern suggests that the first cycle helped students become more familiar with the learning process, while the second cycle provided a more structured environment for participation. In relation to learning achievement, Table 4 and Figure 3 show that 72% of students achieved the passing standard in Cycle I, with an average score of 70.04, and the largest post-test category was Very Well. In Cycle II, Table 6 and Figure 5 show that learning mastery increased to 88%, with an average score of 78.48, and the largest post-test category shifted to With Compliments. These findings should be interpreted as classroom-based improvement across CAR cycles rather than as statistical evidence of causal effectiveness.

The improvement observed in this study can be understood through the instructional structure of Problem-Based Learning (PBL). PBL encourages students to work with authentic problems, construct possible solutions, discuss technical alternatives, and present their reasoning. This structure is relevant to vocational and engineering learning because students are expected to connect conceptual understanding with practical problem-solving activities [7], [9], [14], [16]. In the CAD course, this connection is especially important because students are not only required to operate software but also to interpret design requirements, translate two-dimensional information into three-dimensional models, and make technical decisions during the design process.

The increase in student engagement from Cycle I to Cycle II indicates that students needed time and guidance to adapt to the PBL process. The engagement results in Cycle I suggest that the first implementation of PBL had not yet fully activated student participation. This is reasonable because students who are accustomed to lecturer-centered instruction may initially depend on direct explanation and may not immediately participate actively in open-ended problem-solving tasks. Previous research on first-time PBL implementation has also shown that learning outcomes may change progressively as students become more familiar with the expectations of problem-based learning, including discussion, self-directed inquiry, and responsibility for learning tasks [17]. Therefore, the improvement in Cycle II can be interpreted as the result of both PBL implementation and the refinement of classroom facilitation after reflection.

The engagement pattern in Cycle II also shows that the revised learning strategy provided more opportunities for students to participate in discussions, ask questions, work in groups, and present their solutions. This finding is aligned with research in data-driven engineering education showing that PBL can become a catalyst for student engagement when learning tasks are structured around authentic problems and collaborative activities [18]. In this study, the automotive design problems appeared to function as learning triggers that encouraged students to participate more actively than in the initial condition. However, the presence of one respondent with a score of 0 in the engagement and test data also shows that improvement was not uniform across all students. This indicates that PBL implementation still requires careful monitoring of individual participation, especially for students who may be absent, disengaged, or unable to follow the learning process.

The improvement in CAD learning achievement can also be linked to the practical nature of the learning tasks. CAD learning requires students to develop procedural knowledge, spatial reasoning, design accuracy, and the ability to revise technical drawings. Research on CAD/CAM/CAE learning has shown that design-based learning activities can support technical understanding when students are required to complete design tasks, apply software tools, and connect design decisions with engineering requirements [19]. The present study extends this line of evidence by showing that, in an Automotive Engineering CAD class, problem-based activities may support learning achievement when students are guided to analyze automotive design problems and translate them into CAD-based solutions.

The increase in the average score from Cycle I to Cycle II also suggests that the second cycle provided better instructional support for students. In Cycle I, some students were still less focused and not fully involved in the learning activities. In Cycle II, the learning activities were revised by providing more relevant design problems, improving group discussion management, and strengthening motivation and feedback. This condition is consistent with meta-analytic evidence showing that PBL can support higher-order thinking and learning performance when the learning process includes adequate guidance, appropriate problem design, and active student participation [20]. Thus, the improvement in Cycle II should not be attributed to PBL as a label alone, but to the more structured implementation of PBL after reflection.

The findings also suggest that PBL can support cognitive engagement because students are required to analyze, compare, and justify solutions rather than only follow procedural demonstrations. A pedagogical comparison between PBL and lecture-based instruction has emphasized that PBL provides stronger opportunities for learners to develop cognitive abilities because students are placed in situations that require inquiry, reasoning, and decision-making [21]. This helps explain why the CAD learning outcomes in this study improved after students were repeatedly involved in problem-solving activities. In the context of CAD, such activities are important because students must understand the logic of a design, not merely reproduce a drawing based on lecturer instructions.

Another important aspect is the role of scaffolding and feedback during the learning process. In Cycle II, students were supported through more structured tasks, clearer group organization, and feedback during discussion and presentation. Previous studies have reported that scaffolding in PBL can help students develop creative and higher-order thinking because it reduces confusion during problem solving and helps learners organize their ideas more systematically [22]. In this study, scaffolding was not measured as a separate variable, but the reflection-based improvement in Cycle II suggests that guidance and feedback were important conditions for making PBL more workable in CAD learning.

The findings also have methodological relevance because the study used Classroom Action Research to refine the learning process across cycles. This is consistent with the broader direction of PBL in engineering education, where authentic problems, iterative learning,

collaboration, and reflection are considered important elements for preparing students to solve technical problems [23]. The present study contributes classroom-level evidence from an Automotive Engineering CAD course, showing how reflection between cycles can be used to improve the implementation of PBL and monitor changes in engagement and achievement. This contribution is modest but useful because it focuses on the practical improvement of classroom learning rather than claiming broad experimental effectiveness.

The use of PBL in a CAD course is also relevant to current discussions on digital and technology-supported engineering education. A review of PBL and digital PBL in engineering education indicates that problem-based instruction is increasingly connected with digital tools because engineering students need to develop both technical knowledge and professional problem-solving skills [24]. CAD learning fits this direction because it requires students to use digital design tools while solving technical design problems. Therefore, integrating PBL into CAD learning can help lecturers move beyond software demonstration toward a more active learning process in which students analyze, model, revise, and communicate their design ideas.

From the perspective of vocational education, the improvement in student engagement is particularly important. Research on vocational learning has shown that engagement is closely related to motivation, satisfaction, persistence, and learning outcomes [25]. Another longitudinal study in vocational education and training also emphasizes that student engagement can vary across learners and requires sustained instructional support [26]. These findings help explain why the present study still found individual variation even when the class average improved. In other words, the increase in class-level engagement does not necessarily mean that all students experienced the same degree of improvement. This point is important for interpreting the data proportionally.

Overall, the findings suggest that PBL can support student engagement and CAD learning achievement when it is implemented through contextual automotive design problems, collaborative discussion, presentation, feedback, and reflection. For lecturers, the results imply that CAD learning should not rely only on software demonstration and individual drawing practice. Instead, students need opportunities to analyze design problems, discuss technical alternatives, and explain their design decisions. For automotive engineering education, this study provides practical evidence that PBL can be used as a classroom strategy to make CAD learning more active and problem-oriented. Nevertheless, the interpretation of the findings remains limited to one class of 25 students, two CAR cycles, and descriptive data analysis. Future research should involve larger samples, clearer individual participation tracking, validated engagement instruments, and comparative designs to examine whether similar patterns occur in different CAD or automotive engineering learning contexts.

CONCLUSION

This classroom action research showed observed improvements in student engagement and CAD learning achievement after the implementation of Problem-Based Learning in an Automotive Engineering CAD course. The improvement was reflected in the increase in learning mastery from 72% in Cycle I to 88% in Cycle II, along with an increase in the average score from 70.04 to 78.48. Classroom observations also showed that students became more involved in discussions, questioning, problem-solving activities, group work, and presentations during the learning process.

These findings suggest that Problem-Based Learning can support a more active and problem-oriented CAD learning environment when implemented through contextual automotive design problems, collaborative activities, feedback, and reflection. The contribution of this study lies in providing classroom-based evidence of how PBL can be applied in an Automotive Engineering CAD course to support student engagement and learning achievement.

However, the findings are limited to one class of 25 students, two action cycles, and descriptive data analysis. Future research should involve larger samples, comparison groups, different vocational education contexts, and validated engagement instruments to examine whether similar patterns can be found in broader CAD or automotive engineering learning settings.

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